Illinois Technograph

February 1983 Volume 98, Issue 4
Newstand $1.25

Engineering against the wind

The Chromium Mechanism

The first comprehensive explanation of electrochemical activity during the plating of chromium has recently been formulated at the General Motors Research Laboratories. This understanding has aided in transforming chromium plating into a highly efficient, high-speed operation.

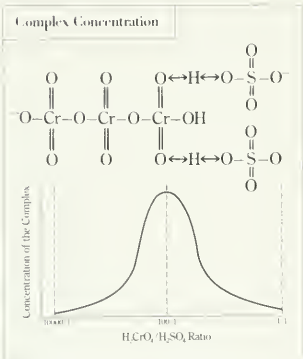
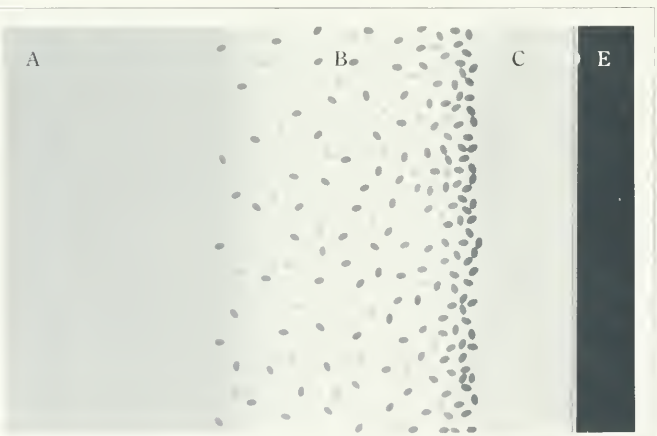


Figure 1. The electroactive complex and a theoretical plot of its concentration as a function of chromic acid to sulfuric acid ratio.

Figure 2. The electroactive complex diffuses from the bulk electrolyte solution (A) through the diffusion layer (B) to the Helmholtz double layer (C) to be discharged as metallic chromium (D) on the cathode (E) surface.



FOR MANY industrial applications, chromium coatings of more than 0.2 mil thickness are required for wear and corrosion resistance. But the conventional method of plating chromium is neither fast nor efficient. Nor, until the recent work of a GM researcher, had the steps involved in the century-old plating process been explained in detail. Through a combination of theory and experiment, Dr. James Hoare has devised the first comprehensive mechanism for chromium plating. This increased understanding has helped electrochemists at the General Motors Research Laboratories develop a system that plates chromium sixty times faster than the conventional method, while improving energy-efficiency by a factor of three.

The electrolyte for plating is a chromic acid solution which contains various chromate ions: chromate, dichromate and trichromate. From a series of steady-state polarization experiments, Dr. Hoare concluded that trichromate is the ion important in chromium deposition.

Sulfuric acid has been recognized as essential to chromium plating and has been assumed by some to be a catalyst for the process. In this strongly acidic solution, sulfate should be mostly present as the bisulfate ion $(HSO_4)^-$. Dr. Hoare found, contrary to expectations, that the addition of sulfuric acid to the plating bath decreased the conductivity of the solution.

Combining these findings with the results of previous investigations, Dr. Hoare concluded that the electroactive species was a trichromate-bisulfate complex (see Figure 1). From equilibrium considerations, he theorized that the maximum concentration of this species occurred at a 100-to-1 chromic acid/sulfuric acid ratio. The observation that the maximum rate of chromium deposition also occurred at this ratio supports the conclusion that this trichromate-bisulfate complex is the electroactive species.

During the plating process, the complex diffuses from the bulk solution toward the cathode (see Figure 2). Electron transport takes place by quantum mechanical tunneling through the potential energy barrier of the Helmholtz double layer and the unprotected chromium in the complex (Cr atom on the left in Figure 1) loses electons by successive steps, going from Cr^{+6} to Cr^{+2}. Decomposition of the resulting chromous dichromate complex takes place by acid hydrolysis to form a chromous-oxybisulfate complex:

$$^{+}\mathrm{Cr{-}O{\leftrightarrow}H{\leftrightarrow}O{-}}\underset{\underset{\displaystyle O}{\|}}{\overset{\overset{\displaystyle O}{\|}}{\mathrm{S}}}\mathrm{{-}O^{-}}$$

The positive end of this complex is adsorbed onto the cathode surface. Electrons are transferred from the cathode to the adsorbed chromium ion, forming metallic chromium and regenerating the $(HSO_4)^-$ ion. Thus, Dr. Hoare's mechanism explains how sulfuric acid, in the form of the bisulfate ion, participates in the plating process.

IT HAS long been known that chromium cannot be plated from a solution when initially present as Cr^{+3} because of the formation of the stable aquo complex, $[Cr(H_2O)_6]^{+3}$. Yet chromium can be plated when initially present as Cr^{+6} even though it must pass through the Cr^{+3} state before being deposited. Dr. Hoare's mechanism handles this paradox by explaining that the chromium ion being deposited (on the left in Figure 1) is protected by the rest of the complex as it passes through the Cr^{+3} state, so that the stable aquo complex cannot form.

The diffusion of the electroactive complex apparently controls the rate of the process, so that shortening the diffusion path increases the speed of chromium deposition. A high rate of relative motion between the electrolyte and the cathode will shorten the path. This can be accomplished by rapid flow or by agitation of the electrolyte.

Dr. Hoare found that the rate of chromium deposition increased with electrolyte flow until the process was no longer diffusion-controlled. He also found that the use of dilute electrolyte significantly increased plating efficiency.

"This project is an excellent example," says Dr. Hoare, "of how basic research and engineering principles can be combined to develop a new, successful process. Now, we'd like to take on the challenge of plating successfully from Cr^{+3}, which would be an even more efficient way to provide corrosion and wear resistance."

THE MAN BEHIND THE WORK

Dr. James Hoare is a Research Fellow at the General Motors Research Laboratories. He is a member of the Electrochemistry Department.

Dr. Hoare served as an electronics technician in the U.S. Navy during the Second World War. In 1949, he received his Ph.D. in physical chemistry from the Catholic University of America. After an assistant professorship at Trinity College in Washington, D.C., he joined the US Naval Research Laboratory as a physical chemist. He became a staff member at General Motors in 1960.

Dr. Hoare's sustaining interest has been in electrochemical kinetics and the mechanisms of electrode processes. He is best known to the scientific community for his basic studies of hydrogen and oxygen electrode mechanisms. His book, *The Electrochemistry of Oxygen*, published in 1968, is considered a work of primary importance to the field. In addition to his work on chromium plating, he is responsible for the fundamental research that helped make electrochemical machining a precision process.

Illinois

Technograph

February 1983 Volume 98 Issue 4

Editor: *Kevin Wenzel*
Production Editor: *Larry Mallak*
Business Manager: *Jim Lee*
Copy Editor: *Charley Kline*
Asst. Copy Editor: *Raymond Hightower*
Photo Editor: *Randy Stukenberg*
Features Editor: *Langdon Alger*
Design: *Nancy Grunthaner*
Assistant Design: *Beth Beauvais*

Publisher: *E. Mayer Maloney Jr.*
Production Manager: *Geoff Bant*
Adviser: *Ed Mast*

Editorial Staff: *Steve Alexander, Rob Busse, Dave Colburn, Doug Campoli, Tushar Chande, Joe Culkar, Tad Dierkes, James Ehrhart, Robert Ekblaw, Jane Fiala, Elayne Fletcher, Mary Kay Flick, Eric Guarín, Pete Kacmarek, Laura Kasper, Chris Konitzer, James O'Hagan, Bill Proctor, John Przybysz, Thom Roe, Doug Shaw, Andrew Saporoschenko, Robert Strahanowski*

Business Staff: Brian Carlson, Jeff Lee, Donna Obermaier

On the cover: A motorcycle, equipped with a Terraplane sidecar and a Windjammer fairing, sits ready to bring a world of adventure to its owner. What kind of company builds in defiance of the wind? Technograph *finds out. (photo by Raymond Hightower)*

Illinois Technograph
(USPS 258-760)
Vol.98 No.4 February 1983

Illinois Technograph is published five times during the academic year at the University of Illinois at Urbana-Champaign.

Published by Illini Publishing Co., 620 East John St., Champaign, Illinois, 61820. Editorial and Business offices of the Illinois Technograph: Room 302 Engineering Hall, Urbana, Illinois, 61801, phone (217) 333-3730.

Advertising by Littel-Murray-Barnhill, Inc., 1328 Broadway, New York, N.Y., 10001; 221 N. LaSalle Street, Chicago, IL., 60601.

Entered as second class matter, October 30, 1920, at the post office at Urbana, Illinois under the act of March 3, 1879.

Illinois Technograph is a member of Engineering College Magazines Associated.


The state of the art in careers.

Editorial

Grad School Provides a Necessary Alternative to Work

Four years is a long time while you are living through it, but once you join the ranks of professional engineers, it will seem like your college days flew by like minutes. After those four long years of all night research sessions, endless hours in labs, and hundreds of problem sets, it seems insane to go on to graduate work. It takes at least another year to obtain a masters degree, and another three years to receive a doctorate.

That's another four years of school on top of the four that you've already struggled through. Four years at the average annual starting salary for a B.S. of $24,816 (as of July 26, 1982) amounts to a gross income of $99,264. That's a lot of money, and to make matters worse, you have to spend money to continue your education.

It seems that from an immediate economic standpoint, it is unwise to continue school after you receive your baccalaureate. The problem is that too many people believe that. There are not enough people graduating from engineering programs with Ph.D.'s to feed both the industrial and academic communities.

The number of Ph.D.'s granted per year has dropped from an alltime high in 1972 of 3774 to the 1981 figure of 2841, according to the Engineering Manpower Commission, AAES, 1981 survey. To compound the decrease in available doctorates, there has been a distinct increase in the number of foreign students working on advanced degrees who will return to their own countries upon graduation. Administrators claim that the figure is as high as 50%.

The great influx of foreign students is not very obvious here at the University. The College of Engineering has been operating under the general guideline of limiting foreign graduate students to 20% of enrollment. The EE department runs at about 17%, while approximately 30% are enrolled in the nuclear engineering curriculum.

Consider the following scenario. There are 2800 Ph.D.'s graduating in a given year. From that group, maybe 1400 will stay in this country. Universities and industry desire the top 20%, narrowing the number to 280. There are about 250 universities who want to hire Ph.D.'s. The result is obvious; industry and universities must compete for the most desired graduates, and universities cannot compete with the pay available in industry.

So who is teaching our classes, and who will be teaching the classes of tommorrow? Obviously, not all of the top people go to industry, but most do, and more tenured professors are leaving universities to join industry all the time.

This trend must be reversed if industry and academia intend to maintain the high quality of engineering research taking place in this country. Industry and universities can work together to curb declining graduate enrollments. Industry can provide more grants and funding for graduate schools. Universities can then use this money to make graduate study more attractive to prospective students.

Students can also work to reverse this trend. Students with outstanding talents, or a desire to teach should seriously consider going on to earn advanced degrees. There is money available to support graduate students; you just have to find it. The Massachusetts Institute of Technology granted $1.8 million in financial aid, assistantships, and fellowsihips to graduate students in engineering in 1981.

Before you graduate, look into graduate school, take the Graduate Record Examination, and send out some applications. Once you are at work, those eight years will seem like they flew by like minutes.

Kevin W. Wenzel

Avoid Hi-Tech Bandwagon, Professor Urges

To the Editor:

Your December, 1982 article (A New Breed of Reactors, p. 12) states that $1.2 billion has been spent on the Clinch River Breeder Reactor (CRBR), and that it carries a price tag of $3.2 billion. It also cites proponents' claims that it is 86% complete. New math?

The CRBR project was originally justified on the basis of a fear that we would soon run out of fissionable uranium. Due to the slowdown of electricity demand during the '70's, this is no longer an urgent problem. The real issue now is whether to spend an additional $2 billion on concrete and steel to finish the project (because the French and Soviets did so), or spend it on researchers' salaries to develop an advanced breeder technology—hopefully one cheaper, safer and more proliferation-resistant than the CRBR's plutonium fuel cycle.

We faced a similar decision 12 years ago with the SST. We opted to scratch the U.S. program and learn instead from the mistakes of the French and Soviets. As a result, talented U.S. engineers were available to develop technology for the super-efficient fleet of subsonic airliners dominating the world market today. As a former die-hard SST supporter, now older and wiser, I caution engineers against jumping on hi-tech bandwagons hyped by politicians, without first analyzing alternative public policies.

Clark Bullard
Associate Professor,
Mechanical Engineering

Illinois Technograph invites letters in response to its articles and editorials, or any other item of interest to our readership. Articles, photographs, and other contributions will also be considered. Letters must be signed, but names will be withheld upon request.

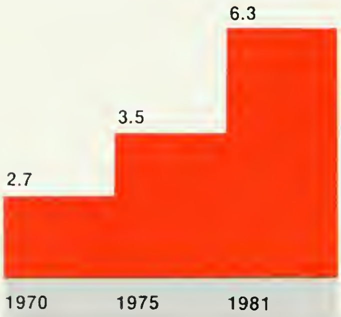
Removing the Over-the-Counter Menace

For everything from "sinus pressure" to "nagging backaches," pills have become an essential part of an American's needs. Keeping these pills secure from tampering has recently developed into a problem. The solution to this problem involves everything from economics to psychology.

The growing tendency of the American public to rely on tablets, capsules, and lozenges for relief from various illnesses and discomforts has resulted in skyrocketing profits for producers of drugs and pharmaceutical supplies. Since the well-publicized Tylenol poisonings, however, the public outcry for these cure-all pills has been matched by another demand: tamper-proof containers.

Late September saw the deaths of seven Chicago area residents as the result of cyanide-laced Tylenol capsules. Although the exact debasing of the drug still has not been determined, investigators now feel that Tylenol capsules were purchased, opened, and filled with cyanide. The capsules were returned to the bottle, then randomly distributed on the shelves of drug stores along Illinois State Route 53.

Sales of
Over-the-Counter Drugs
billions of dollars



Efforts to thwart future attempts at drug sabotaging have taken several forms. Authorities have urged improvements in communication to warn consumers of potential dangers sooner, sought stricter laws to control the sale and packaging of non-prescription drugs, closely watched local-level drug distribution, and have urged manufacturers to develop "tamper-proof" containers. Such containers can serve to deter potential poisonings by making it easy for the consumer to spot previously opened boxes and bottles.

"They should've had them a long time ago," said Derryl G. Singley, Registered Pharmacist for Cavett Drugs in Champaign, Illinois. "I was always surprised Tylenol didn't (have tamperproof bottles), being such a large supplier. Anacin 3 has already come out in tamperproof. It's about time. Even grocery stores are beginning to see them. There are too many chances for some cuckoo to do something," he explained.

Anacin 3's tamperproofing consists of a special piece of cellophane tape over the lid of the box and a warning to consumers to beware if the seal is broken. Other drugs, such as Ecotrin, used this method even before the Tylenol cases. "People will always be opening boxes to see what's inside," cautioned Singley. "We watch them (the customers) as best we can, but some still get by undetected."

Some drugs, such as St. Joseph's aspirin, come in boxes which are glued shut. Another remedy would involve encasing the entire box in cellophane, as phonograph records are now sealed.

A different type of tamperproof container which has already been in use is the plastic blister pac. This arrangement, commonly seen in boxes of Contac, encases each capsule in a foil and plastic bubble which must be broken to remove the pill. Although this system is most readily adapted to protection of drugs, their manufacture is expensive. Scott Ricci, Registered Pharmacist for McBride's in Champaign, Illinois, said, "(The blister pac) is ideal, but it is more expensive. I think you will definitely see a cost increase as a result of the new tamperproof containers."

Additional tamper-resistant seals may be located over the mouth of the container, under the lid. Paper, foil, or plastic covers must be broken to get to the pills. Another system requires the container to be vacuum sealed, so that once the lid is removed, the seal would visibly bulge. Both of these methods would deter tampering by making access to the pills without readily apparent rips or tears nearly impossible.

Tamperproof lids, such as those currently found on many beverage bottles, are also being examined. These lids separate into a removable cap and a metal ring which stays on the bottle when opened.

The shrink wrap already used on many grocery items is another potential deterrent to drug tampering. This method covers the lid and the neck of the bottle with a sheet of plastic which melts and shrinks when exposed to heat. To remove the lid, the plastic must be removed, leaving obvious signs of tampering.

Similar to this is a method which, along with the box seal and paper liner, will soon be employed on Tylenol containers. By using a plastic ring of tape around the bottle lid joint, the container cannot be opened without breaking the seal and leaving apparent remains. Nevertheless, cautions Ricci, "It will be up to the consumers to closely examine what they buy for signs of tampering."

Besides tamperproof containers which leave tell-tale signs of handling when opened, the pill itself is being examined for tamperproof modifications.

The easiest form is not a capsule at all, but a tablet. Aspirin tablets already are known well in this form. "The tablet form is tamperproof," explained Ricci. "Still many people prefer the capsule. I guess they find it easier to swallow." Johnson & Johnson has another theory: they feel capsules can help cure people simply because they look more like prescription drugs, and thus have a psychological effect similar to kissing a child's hurt knee.

Proportions of 1981 Sales
(in percents)

Source
Product Marketing Proprietory Association

To meet this market, several tablet types have been developed. The soft gelatin capsules currently used for liquid drugs, such as vitamins A and E, will leak and self-destruct if tampered with. Locked capsules are also being experimented with: the two-piece tablet is sealed with a special band, making it impossible to take apart and reseal the capsule at will.

While many tamperproof containers have already appeared on the market—even prescription drugs are sealed—more are soon to follow. Consumer demand will necessitate some changes as various competitors fight for Tylenol's 35 percent market share. In fact, when Tylenol is reintroduced, it will have three tamperproof seals. "...they may be going a little overboard with three seals," notes Singley, "but if they want to regain 75 percent of their previous market, as they hope to do, they have to regain the customers' trust."

Change will also be forced by local, state, and federal regulations. Chicago Mayor Jane Byrne has demanded that within 90 days, all drugs sold in Chicago are to be in tamperproof containers; former Attorney General Tyrone Fahner has recommended that the state government adopt similar legislation. Massachusetts introduced laws in early October to the same extent, which would also require state inspection of random samples. Drug-company executives and Food and Drug Administration (FDA) authorities have formed a committee to channel these local laws into national guidelines. This will eliminate conflicting regulations and limit those which are impractical.

Although these new safeguards will cost the consumer millions of dollars in price increases of one to two percent—Tylenol's new packaging alone will cost 2.4 cents per bottle—they have already resulted in profit for packaging firms. Time magazine reported that Anchor Hocking Corporation has seen skyrocketing demand for vacuum-glass jars, PCM Corporation expects a large demand for its plastic blister pacs, and Milwaukee's Tiny Pillar Corporation is struggling to keep up with orders for its sealing machinery. Similar gains have been seen in the stock market, as analysts see increased demand for the new containers.

Despite these safeguards, a truly tamperproof container is unlikely. Hypodermic needles could penetrate many barriers leaving a hole visible only under close scrutiny. Some barriers are easily replaced with simple machinery, and others such as glued or taped boxes are defeated with everyday materials like razor blades, cellophane tape, and white glue. Furthermore, unless consumers are alert to the absence of tamperproof barriers, they could be removed entirely and not be missed. Said FDA chief Arthur H. Hates, "...it is impossible to make clear that a tamperproof package is not possible."

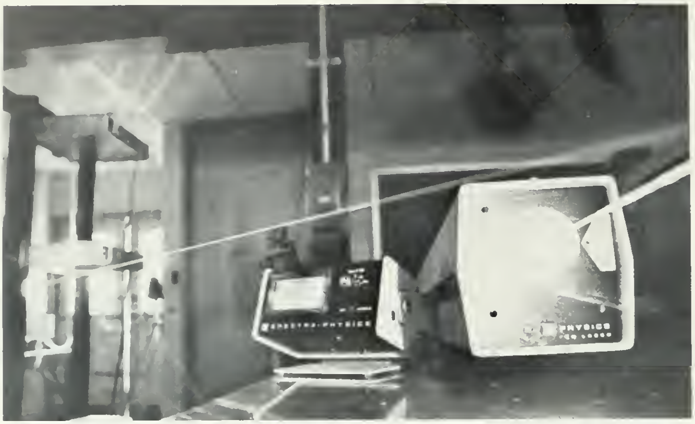
Still, the development of safeguards will tend to re-assure the public and deter all but the most determined maniac. "I think they'll be effective," said Ricci. "Not completely foolproof, but they'll help."

Whatever the final form of the tamperproof containers, they cannot be effective solely by themselves. Consumers must look at the medicine they take and the seals containing them; the FDA is outlining a new system for faster reporting of poisoning cases; the federal government expects to have packaging guidelinges available soon. Possibly, through a combined effort, the threat of similar crimes can be reduced.

Although the Tylenol tragedies have left a grim image on the drug industry and the general public, changes have arisen which will result in more respect, higher standards, and a greater degree of safety in the pharmaceutical industry. ■

Tushar Chande

The Multifarious Laser



This is the second part of a two part series on laser processing. The first part appeared in the November, 1982 issue.

"LASER", the acronym, has become a noun. It's listed as "a device that amplifies light waves and concentrates them in an intense, penetrating beam"[1]. With laser applications on the rise, the re lated glossary is expanding too. Soon, "laser" the noun must grow into a verb, even take on a suffix or two. In anticipation, we provide "-ation", a suffix mean ing "to act, condition or result from"[1]. Laseration would generically include transformations brought about by laser processing, or lasering.

Why is laseration worth knowing ab out? Because it involves jobs and money. *Newsweek* magazine in its November 18, 1982, issue estimates that by the end of the decade, there will be up to 600,000 new jobs in industrial laser processing. Being high-tech jobs, they require skills which net good salaries. The long term outlook is good—in tune with the changing nature of the American workscape.

Lasering means doing it with precision and intensity. Precision is as high as can be obtained by numerically controlled instruments. Intensity was first measured in "gillettes", the number of shaving blades that could be burned clean through. Today, intensity is quoted in watts per square centimeter. Typically, laser intensities approach a million watts per square centimeter. To get this power per unit area, a conventional light source would have to emit a staggering total power of approximately a million watts. This means that while the ordinary 200 watt light bulb cannot melt metal, a continuous laser with the same power can.

The laser-material interaction depends on the nature of the laser as well as the properties of the material itself. The wavelength of the laser beam, its power, beam diameter and spatial distribution play important roles. The reflectance of the material surface, its absorbency, the ability of the material to conduct heat, and the quantity of heat required to bring about a phase change in the material determine its response to laser irradiation.

The wavelength of the laser determines how well it can be focused. Also, lower wavelength lasers couple better with metals. The power and beam diameter determine the power density in the beam. The power density distribution is crucial in materials processing. Materials with lower surface reflectance tend to fuse much easier with the aid of laser radiation. A material that is an efficient conductor of heat is difficult to melt, as is a material with a large latent heat of fusion. The choice of a laser system depends on the material to be processed and the particular application.

Laseration can be classified by the maximum operating temperature attained. Desired transformations could be obtained by heating above room temperature but below the melting temperature, as in laser heat treating. Laserations involving a melting step are welding, cutting, alloying, cladding and glazing. Drilling and marking requires melting and vaporization of the substrate.

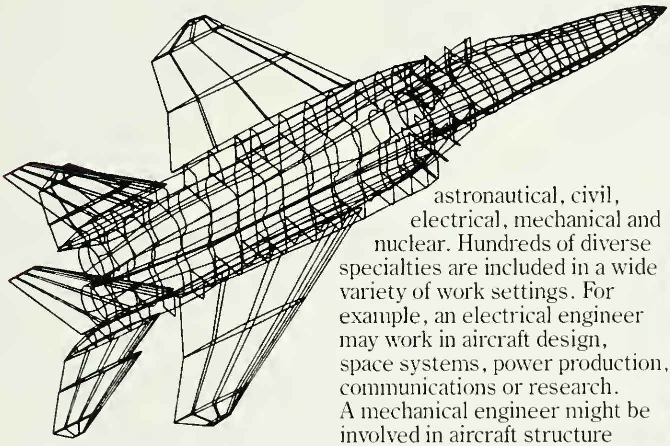
Laseration enjoys many advantages over conventional production processes. Since a beam of light is used, no actual contact between the "tool" and the "workpiece" occurs, a feature that adds flexibility and versatility. The high intensities permit rapid, localized heating, reducing distortion and making precise operations possible. It is clean, and responds instantly to commands altering its speed or power.

The laser beam has a relatively large depth of focus, and permits easy handling of complex shapes and structures. It can be transmitted through air, and made to reach all optically accessible areas. Laser settings are reproducible and a single beam can be used at multiple workstations using suitable optics. Operational safety can be readily assured, and high rates of productivity can be easily attained.

However, the laser system is a major capital expense, and does not cut costs significantly as a direct substitute to a conventional process. But, its unique properties can be exploited to develop new processing methods that yield qualitative and quantitative advantages over existing ones. This is their strength, and for the innovative engineer, this is the dream beam.

continued on page 12

ENGINEERING TAKES ON EXCITING NEW DIMENSIONS IN THE AIR FORCE.



Computer-generated design for investigating structural strengths and weaknesses.

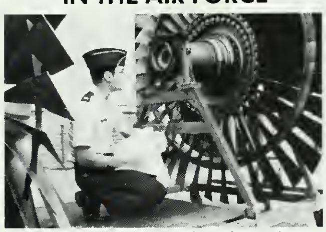
Developing and managing Air Force engineering projects could be the most important, exciting challenge of your life. The projects extend to virtually every engineering frontier.

8 CAREER FIELDS FOR ENGINEERS

Air Force electrical engineer studying aircraft electrical power supply system.

Engineering opportunities in the Air Force include these eight career areas: aeronautical, aerospace, architectural, astronautical, civil, electrical, mechanical and nuclear. Hundreds of diverse specialties are included in a wide variety of work settings. For example, an electrical engineer may work in aircraft design, space systems, power production, communications or research. A mechanical engineer might be involved in aircraft structure design, space vehicle launch pad construction, or research.

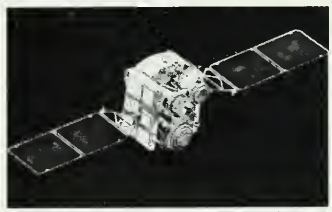
PROJECT RESPONSIBILITY COMES EARLY IN THE AIR FORCE



Air Force mechanical engineer inspecting aircraft jet engine turbine.

Most Air Force engineers have complete project responsibility early in their careers. For example, a first lieutenant directed work on a new airborne electronic system to pinpoint radiating targets. Another engineer tested the jet engines for advanced tanker and cargo aircraft.

OPPORTUNITIES IN THE NEW USAF SPACE COMMAND



Artist's concept of the DSCS III Defense Satellite Communications System satellite. (USAF photo.)

Recently, the Air Force formed a new Space Command. Its role is to pull together space operations and research and development efforts, focusing on the unique technological needs of space systems. This can be your opportunity to join the team that develops superior space systems as the Air Force moves into the twenty-first century.

To learn more about how you can be part of the team, see your Air Force recruiter or call our Engineer Hotline toll free 1-800-531-5826 (in Texas call 1-800-292-5366). There's no obligation.

AIM HIGH
AIR FORCE

Mary Kay Flick

The Ins and Outs of Water Towers

Anywhere a person travels in this country, rural town or sprawling metropolis, a water tower is almost always one of the things that is noticed. After all, a structure as large as a water tower isn't easily missed.

A water tower has two main functions. First, it balances the fluctuations between the water supply and demand. Second, it acts as a safeguard to insure an adequate and continuing source of water in case of a breakdown in the system. The use of elevated tanks also reduces pumping costs (due to gravity, the pump is required to do less work). Storage tanks are also used for fire protection or advertising. A small system can be placed either near the center of a large demand area, or opposite the pumping station with a large demand area in between. With a large system, several tanks are used in the center of each area of heavy demand.

Water towers are normally made from two basic materials: concrete and steel. Both have their advantages and disadvantages. Most concrete tanks are made of a pre-stressed concrete, which is circular in shape at ground level. The tank is pre-stressed by winding a high-strength wire around the core wall of concrete. After the wire is wrapped, a pnuematic mortar is applied to the outside wall to bond the wire to the wall and protect against corrosion. Thanks to this process, concrete tanks have fewer maintenance problems with respect to corrosion, but they are more susceptible to damage from rapid and severe temperature fluctuations, which makes them more susceptible to leaks.

In steel tanks, on the other hand, the constant problem of corrosion must be dealt with. Corrosion can be caused by rust deposits or by deposits which result from the presence of minerals in the water. Because of this, some sort of cathodic protection must be provided. One advantage of steel structures is that due to their elevaton, the pressure created by gravity is greater.

Steel structures are those most easily seen and most widely used in Illinois. Because few areas in Illinois have a high enough elevation to facilitate a concrete ground based storage tank, elevated water towers must be used. There are some ground tanks (standpipes) made of steel, but most are elevated.

Water towers of steel can be constructed in many different shapes and sizes. Most are spherical, and are supported by one or more columns. The largest manufacturer of steel storage structures, Chicago Bridge and Iron Company, makes several different designs, depending on the needs and resources of the area.

The four major design types are: (1) a spherical or cylindrical tank mounted on a large fluted or plain column ("Watersphere ™" or "Waterspheroid ™"), (2) a spherical tank mounted on a thinner center column with extra support from five smaller columns (ellipsoidal, or spheroidal), (3) a cylindrical, funnel shaped design on a tripod of columns (Tripod ™), and (4) steel ground reservoirs and standpipes. If the water source is relatively near, then the first three designs are used according to the needs of the area. When the water supply is obtained from a distant source, ground reservoirs and standpipes are needed. They assure an adequate supply whenever water is needed.

The difference between a standpipe and a ground reservoir is simply their shapes. A ground reservoir has a diameter wider than its height, whereas a standpipe has a height greater than its diameter. So, there is a storage tank shape to meet every need.

Each shape may also be built in several different capacities. The single column structure can range in capacity from 25,000 gallons to 2,000,000 gallons. Multiple column tanks also range in capacity from 25,000 to 2,000,000 gallons. The smaller tripod tanks start at 15,000 gallons and can only reach a capacity of 100,000 gallons. Therefore, the type of tank used also depends on the amount of water needed to meet the demands of the area.

Constructing a water tower entails a sizable outlay of funds for an industrial plant or a municipality. Estimates given by Chicago Bridge and Iron Company (CBI) show that a 100,000 gallon tank with a 100 foot depth would cost approximately $175,000. A 500,000 gallon tank would run about $400,000 while a one million gallon tank for industrial fire protection would cost about $800,000.

continued on page 12

continued from page 10

CBI receives orders for about one to three structures per month; the most common ones being built are the 100,000 to 500,000 gallon capacity structures. Some structures, like those in Champaign-Urbana, are owned by the water companies who use them. Champaign's are owned by Northern Illinois Water Company which is therefore responsible for their maintenance.

The inner workings of water towers are hidden from the outside so their internal processes often are unknown. As stated, water towers are used to regulate daily consumption, insure an adequate supply, provide fire protection. Water is pumped from the source at an hourly rate according to relative peaks and lows in demand. The amount of water kept in a tower is usually one third to one sixth of total demand. This is determined analytically or graphically by water supply engineers.

Leakage, which also must be taken into acount, is determined to be about ten percent of water consumption and fire demand. The amount used is also determined by the area where the tower is located relative to the source and the center of demand. For example, a business zone of a city may need high pressure from water mains to keep up with demand. Although in industry, the major purpose for towers is fire protection, they may also be used when an adequate supply of water is necessary for safe and efficient production.

Once a storage structure is built, its most pressing need is maintenance. If properly maintained, a water tower can last anywhere from twenty-five to fifty years. The major problems concerning maintenance are the reduction of leaks, protection from external weather damage, and protection against icing damage.

Steel tanks must periodically be emptied, cleaned, inspected, and repainted as required. On the outside, a rust-inhibitive primer and two coats of long oil alkyd enamel or long oil spar varnish aluminum are used. On the inside, a number of vinyl epoxy ester, catalyzed epoxy and other paint systems may be used. The structures also need protection. Maintenance people supply this protection by maintaining properly varying water levels or perhaps through the use of internal heaters. In addition, towers must constantly be watched for leaks.

However, the problem most dealt with in water storage maintenance is protection against corrosion. Corrosion may be in the form of mineral deposits or, more commonly, in the form of rust which may corrode the steel in the tank. Corrosion occurs when a scratch or nick develops in the protective coating and base steel is exposed.

Cathodic protection consists of metal rods of a metal more reactive than the steel in the tank. Because of their higher reactivity, these rods corrode away instead of the sides of the tanks. The metal rods, called anodes (the steel sides are cathodes in the chemical reaction which takes place), must be replaced periodically to insure continuing corrosion control.

Water towers are not simply mammoth structures to indicate the name of the city to those passing through it. They serve to maintain an adequate supply and quality of water whether it is needed for public use, industrial use, or for fire protection. While they are extremely functional, they can be made to add interest and character to the area which they serve. ■

continued from page 8

In materials processing, lasers have been used to weld, cut, heat-treat, drill, mark, shape, machine, hardface, alloy, shock-harden, and anneal. They have also been used to punch holes in cigarette paper, cut cloth for men's suits in the garment industry, drill holes in ceramics, strip insulation from wires and to trim resistors in elecronic circuits.

Metals such as titanium are easily cut by lasers in the presence of a reactive gas. Laser cutting is cleaner, smoother and more accurate than conventional methods. The cut has narrow kerf widths and more parallel sides. There is minimal distortion and waste. The Grumman Aircraft Corporation has been using lasers in production for nearly a decade, and rough trimming costs have been cut 60 to 80 percent. Also, simple holding and positioning tools can be used, as the process exerts almost no cutting pressure on the part being trimmed[3].

Automobile exhaust valves readily show that the automotive engine provides adverse working conditions for a part. General Motors uses laser surface alloying to alloy exhaust valve seats. A cost analysis of laser alloying versus conventional hardfacing techniques suggests that cost savings of up to 80 percent can be achieved[4]. Pistons, camshafts, and gear teeth are other automobile parts that can be laser surface treated for improved performance at significant cost reductions.

As an example of the problem-solving potential of lasers, consider the welding of aluminum-magnesium alloys. Such alloys are good conductors of heat, and thus a large quantity of heat is required to melt them. The high temperatures that are reached cause the magnesium to boil off, leaving a porous, unsound weld. Researchers at the University have shown that it is possible to laser weld these alloys in combination with appropriate gas shielding procedures to produce sound welds with little porosity and low magnesium loss[4].

Another interesting recent development is the use of lasers in the recrystallization of thin film semi-conductors. Thin films of semi-conductors can be overlayed on a silicon substrate to develop three dimensional integrated-circuits. The laser beam can also be used to anneal semiconductors during manufacturing, especially in VLIC and VHSIC applications, when the scale of processing would seriously limit furnace methods. These are still not part of a production process, but point to future trends.

The potential of the laser in industry is only just being tapped. The powerful pencil of light has a bright future. ■

REFERENCES:
1. Webster's New World Dictionary.
2. L. Michael Heglin, in "Applications of Lasers in Materials Processing", E. A. Metzbower, ed., ASM(1979), p. 101.
3. John Huber and Warren Marx, ibid, p. 273.
4. David A Belforte, Colloq. on Lasers and Electro-Optical Equipment, Tokyo, Japan, 24 Oct., 1978.
5. A G Blake, MS Thesis, University of Illinois, 1982.

Tech Teasers

1. A 1982 newspaper stated that a man died when his age was one twenty-ninth the year of his birth. How old was he in 1952?

2. Crafty Constance Carter's candid instructor Carl told her to "form the number ninety-two from x and y, given that $x=2514$ and $y=-2422$." Obviously, one would assume that she would have added x and y, because $2514-2422=92$. However, being a card, like her sister Candy, Constance said "No. I can create ninety two out of just one of the numbers you gave me." The teacher, Carl, and Constance's classmates watched in amazement as she did just what she said she could. What did she do? There can be no rearranging of the order of the digits of x or y.

3. Can you imagine a rope ladder (you know the kind—knotted rope, wooden rungs, right?) hanging down the side of a ship? Good! Now imagine that the ladder is 40 feet long, and the tide is out. Suppose the tide comes in at the rate of 5 feet an hour, and the distance between rungs is 2 feet. If the water level starts below the ladder a distance that is one-fifth the length of rope that will be left unwet after the tide comes in, how many steps of the ladder are underwater if the tide comes in for 3.5 hours?

answers on page 18

Technotes

Tau Bates and Legislators

Seven Illinois legislators were the guests at Tau Beta Pi's First Annual Legislative Forum last December 6. The forum was intended to benefit both the legislators and the students involved, and it did exactly that.

The event lasted all day, and it started with a brief registration. At this time, the guests were welcomed, given information packets for the day, and Robbie Rubik was on hand to solve a puzzle simpler than most political ones. Then the legislators were taken on a tour of the University's high technology laboratories.

After the tour, everyone sat down to a special luncheon, at which President Ikenberry and Chancellor Cribbet gave speeches. Then the afternoon rolled around, and it was taken up by panel discussions. These discussions were probably the most educational and informative for both students and legislators. The talks were informal; each was conducted between two legislators and about eight students. To conclude the day, all parties enjoyed a banquet, and this time Dean Drucker was the speaker.

The forum was extremely well received, and every one of the legislators commended TBΠ's excellent job and encouraged its continuation. As a result of the forum's success, it was decided that it would become an annual event for many years to come.

The Bomb

The Physics Department here at the University tends to offer excellent courses, including one that can really have some explosive subject matter. The course is PHYCS 199, "The Bomb—A Beginner's Tour of Nuclear Weapons, War, Strategy and Arms Control."

Last Fall, the course was taught by twelve professors from the physics, astronomy, and nuclear engineering departments. This fall, professors from other non-technical fields will hopefully help in the instruction. The enrollment last fall was 65 for credit and twenty auditors. It dropped to only fifteen by the middle of the semester, probably because the course delved deeply into technical areas early on.

The semester was divided into four units, which included the nuclear arms race, the future, nuclear weapons themselves, and terrorism and proliferation. Various topics were discussed and presented during these sections, including the consequences of a nuclear war and an attack on a nuclear power reactor. The goals of the course seem to hinge on awareness. In a course such as this, politics may be somewhat removed by concentrating on the technical aspects of the subject, and this was the method the instructors used. The professors presented facts, and tried to stimulate awareness, conversation, and thinking about the entire nuclear arms situation, in hopes of helping to bring about a safer world. Professor of physics and astronomy Frederick K. Lamb, who organized the course, feels that it is necessary for educational institutions to provide such instruction since informed and concerned citizens are vital to society.

Lamb said the course was conceived through several meetings of concerned scientists last spring. All the people involved provided a tremendous amount of help in getting the course started. Physics 199 is a giant step in the right direction which will bring awareness of this important issue to society.

Langdon Alger

SCIENCE/SCOPE

Two communications satellites made history as the first to be launched from NASA's space shuttle. The first of the pair, SBS-3, is operated by Satellite Business Systems and will carry high-speed data for many U.S. companies. The second, Anik-C, is operated by Telesat Canada and will improve telephone, television, and data service in Canada. The satellites are versions of Hughes Aircraft Company's HS 376, the world's most widely purchased communications satellite. Hughes now has built 70% of the world's operating commercial communications satellites and has more successes than all other companies combined.

A safety device that snuffs out explosions in the blink of an eye, originally developed for the military, is being applied commercially where fire poses an immediate threat to human life. The Dual Spectrum™ sensing and suppression system has been evaluated in New York Transit Authority toll booths. It detects fire bomb explosions set off by criminals, and suppresses them in one-tenth of a second -- before transit employees can be injured. The system could be applied almost anywhere fire explosions occur within an enclosed area. It was developed by the Santa Barbara Research Center, a Hughes subsidiary.

The Smithsonian Institution is installing a new security system to monitor many facilities continuously. The Hughes system includes burglar alarms, fire-sensing devices, voice communications channels, and closed-circuit TV. It will let Smithsonian personnel control entrances and exits, and watch over areas open to visitors. A computer will collect and display information on TV monitors and printers at a central control station. Hughes previously installed a facilities management system at the Smithsonian's National Air and Space Museum. That system provides a wide range of exhibit monitor and control functions.

The new thematic mapper aboard Landsat 4 has distinct advantages for mapping vegetation and land covers in comparison to the multispectral scanners used on previous Earth resources satellites. Improvements give the instrument better resolution (30 meters versus 80 meters) and enable it to see in narrower bandwidths. The green band measurers reflections from vegetation more precisely. The red band better distinguishes differences in the chlorophyll absorption of plants. The near-infrared spectral band reduces the chances of atmospheric vapor like fog and haze from obscuring land surfaces. Hughes and its Santa Barbara Research Center subsidiary built the thematic mapper from NASA.

Hughes needs graduates with degrees in EE, ME, physics, computer science, and math. To find out how you can become involved in any one of 1,500 high-technology projects ranging from subminiature microcircuits to advanced satellite technology, contact: College Relations Office, P.O. Box 1042 (C2/B178-SS), El Segundo, CA 90245. Equal opportunity employer.

Against the Wind

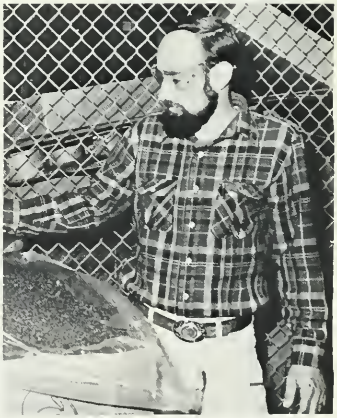
Windjammers are manufactured by the Vetter Corporation, which is located in Rantoul, Illinois. At one time, there was a Vetter factory in San Luis Obispo, California, but the plant was closed in 1978. Vetter products can be found at over 3700 dealerships in the United States, and motorcycle enthusiasts in foreign countries can order Vetter products through overseas distributors. Last year's sales totaled $31 million, which makes Vetter the leading manufacturer of fairings in the country. Other Vetter products include lightweight helmets, sidecars, luggage, and protective gauntlets known as "Hippo Hands".

Vetter was founded in 1968 by Craig Vetter, who earned his degree in industrial design here at the University. Vetter, Charlie Perethian, and Dwayne Anderson were the chief designers of the company's early products. In 1978, Craig Vetter sold the Vetter Corporation in its entirety to Rick Binet.

Craig Vetter hasn't given up motorcycling, however. Each year he and the Central Coast Motorcycle Association sponsor the Craig Vetter High-Mileage Contest. Vetter, along with several major manufacturers, supplies a total of $4,000 in prize money for the various events. This year's run was made along the 135 mile stretch of highway between San Luis Obispo and Carmel in southern California. Several teams entered the contest, each with its own exotic fairing design. Vetter was quoted in the November 1982 issue

A fairing is a structure used on a vehicle to reduce drag. To most motorcycle riders, the words "fairing" and "Windjammer" are nearly synonymous. This is not surprising; studies have shown that the Windjammer outsells its nearest competitor by more than two to one. But what of the company behind the Windjammer?

Above: Vetter accessories on display at a local cycle shop. (photo by Randy Stukenberg)
Right: The ABS scrap is granulated and prepared for shipment to the recycling facility. (photo by Raymond Hightower)



Raymond Hightower

Left: Before they are painted, all fairings must be sanded in order to insure a smooth, aerodynamic finish. Vetter employees in one section of the facility are responsible for this step. (photo by Raymond Hightower)

of *Cycle Guide* as saying, "I'm sponsoring contests to encourage people to believe it's okay to use less energy."

Energy conservation is not the only reason why a motorcycle owner might choose to purchase a fairing. There are other considerations. First of all, fairings provide protection against the elements. A steady flow of wind at the legal highway speed limit of 55 mph can introduce a high wind chill factor. Second, a fairing is an excellent place to store items such as a stereo, CB radio, or odds and ends. Ideally, a fairing should do nothing to change the way the motorcycle handles.

The fairing manufacturing process in itself is fascinating. The raw materials come from many manufacturers throughout the United States. The basic material used in all Vetter fairings, with the exception of the Ghost, is Acrylonitrile Butadiene Styrene (ABS). ABS arrives at the facility in sheet form, the length, width, and thickness of which are specified by Vetter prior to shipment.

Upon arrival, the ABS sheets are taken to one of the two rotary vacuum formers in the plant. The rotary vacuum formers, like most of the plant's equipment, were designed and built by Vetter employees. The machine consists of three main stations: the input/output station, the heating station, and the forming station.

As its name implies, the input/output station is the place where the sheets are initially laid. After the sheet has gone through the remaining two stations, it returns to the input/output station for cooling and removal.

At the heating station, the sheet is heated to temperatures in the range of 250° Fahrenheit. When exposed to this high temperature, the sheet becomes soft enough to be put through the molding process.

The sheet is moved to the vacuum former station to be molded into the desired shape. After the forming stage, the product is moved to the input/output station where it is cooled and removed.

Only one-sixth of the material that goes through the rotary vacuum former is used in the final product. The extra five-sixths is necessary because the vacuum former, being an automatic machine, needs something to "grab on to". Since humans will be doing most of the handling from this stage onward, the extra material is band-sawed off the product. This scrap is run through a granulator and then sent back to the supplying company to be melted into new sheets. Thus, there is little waste.

The product, which now has the basic appearance of a finished fairing, is taken to another room to be sanded. When all blemishes have been removed, the product is coated with a polyurethane-based paint which is allowed to harden for one to three days.

When the paint has hardened, the fairing parts are taken to another area of the plant for assembly. A bonding agent developed by Vetter chemists is used to hold the parts together. In ideal situaions, that is, with perfect temperature and humidity, the bonding agent will harden in about 14 minutes; but it is allowed to cure for 30 minutes just to be on the safe side. After the adhesive has cured, a second measure is taken to insure that the fairing parts are safely bonded together. The fairing is put through an ultrasonic welding process.

Next the product is taken to an automatic drill, another Vetter-designed manufacturing tool. Forty-three holes are drilled simultaneously, while a worker rounds the edges of the product with a router.

The pick-and-fill process follows the work with the drill and router. Any small gouges which developed during the earlier steps of production are filled with a substance made especially for this stage. Next comes the semi-final inspection. The fairings are reviewed individually for mistakes; any imperfections are marked with a grease pen by the quality control people. Once pointed out, these flaws are corrected.

continued

continued from page 17

Fairings which pass the semi-final inspection are then treated to an array of finishing touches. These include the installation of wiring, the application of edging and striping, and finally, the applicaton of the fairing insignia, i.e. Windjammer, Quicksilver, etc. Next the product must go through a rigorous final inspection under the watchful eyes of twenty-six quality control people. Imperfect fairings are sent to the proper department for corrections, or possibly destruction. If the product makes it through the final inspection, as most do, a serial number is applied. Finally, the fairing can be packaged for shipment.

Products other than fairings undergo a manufacturing process quite similar to the one described above. Differences include the type of mold used in the vacuum former, the number of holes drilled by the auto-drill, etc. Some products, such as the Ghost fairing, are molded by a drape-former instead of a vacuum former.

The Ghost is made from a sheet of transparent acrylic which is cut to size and laid on a mold. The mold rests on a conveyor which runs through an oven. As the temperature of the acrylic rises, the sheet becomes soft, and it collapses under its own weight. Normally, this would be catastrophic, but since the sheet is sitting on top of a mold, it merely collapses into the desired shape.

Product safety plays an important part in design and marketing decisions at Vetter. Of course, before such decisions can be made, the finished product must be put through rigorous testing. The test subjects are picked off the assembly line at random; products which have undergone testing cannot be sold because the tests are destructive. These tests can range from the high-tech type using sophisticated electronic test equipment to the more exotic tests in which a rider rides over a series of railroad ties.

Newly introduced products are put through the most rigorous of tests. One of the latest Vetter products to go through this initiation was the Terraplane sidecar. Vetter had planned to market a sidecar a few years back, but they scrapped the project for safety reasons. The Terraplane design, however, looked promising. The prototype was built in 1980, and put though extensive road tests. Then came the final challenge.

On January 6, 1981, two test riders departed from the Vetter facility in Rantoul. One rode the bike, the other rode in the Terraplane. Their mission was to put the Terraplane through all possible driving conditions: rain, ice, snow, cold, etc. Based on the information gathered on this trip, a manual for potential owners and operators was written. Experience is the best teacher, especially in cases such as this.

It's obvious that there is a lot more to a fairing than a simple description could explain. And what of the company behind the Windjammer? Behind it, there's a company full of people, and each product is a result of their combined efforts. Managers, designers, inspectors, etc. all put in their share. But when a biker is cruising on the highway, enjoying the smoothness of the road and the beauty of the scenery, these things are furthest from his mind. It's much more comforting to relax and enjoy the ride. ■

from page 13

Tech Teasers Answers

1. If z is his age at death, then $29z$ is his date of birth. His date of birth plus his age at death will yield his date of death, or $29z + = 30z$. Since he was alive in 1952 and dead by 1982, which is information gleaned from the question, he must have died between these two dates. His death date must be divisible by 30, so the date of death must be 1980. $1980 \div 30 = 66$. $1980 - 66 = 1914$, so he was born in 1914 and was 38 years old in 1952.

2. Constance simply took $x = 2514$, and converted it into its hexadecimal equivalent. 2514 in base ten equals 9D2 ("nine-d-two") in base 16.

3. Since it is a rope and wood ladder, the ladder will float on top of the water. Thus, none of the ladder will ever be underwater.

Bring Out Your Best At

It took pride, talent and a commitment to excel in all you do, to take you where you are today. That's why you're determined to find a career that brings out your best, a career that offers challenge and room for growth, both personally and professionally.

At Anheuser-Busch, we've been bringing out the best in talented people for over one hundred years, with stimulating projects and a commitment to quality that inspires superior achievement.

You can make the most of our talents in one of these positions:

Central Engineering
B.S.M.E.—M.E.'s will gain experience in such diverse fields as material handling, equipment layout, piping system development, steam generation, compressed air systems, ventilation, heating and air conditioning, and high speed bottle and can packaging.

B.S.E.E.—E.E.'s can expect to work in such areas as electrical machine design and application, power distribution, sub-station layout as well as industrial and commercial lighting, electrical control circuits and systems control.

These positions are project-oriented and allow you the opportunity to work on a project from conception to completion.

Corporate Management Trainee Program
The Corporate Management Trainee Program comprises various divisions of Anheuser-Busch Companies, Inc. Under this one year program trainees will receive "hands-on" first line supervisory experience in specific areas of the company. Trainees will also be exposed to various management concepts by attending several management development seminars.

Trainees are evaluated on their knowledge of the company and their ability to apply this knowledge as demonstrated by several written reports and the ability to function in various job assignments.

Upon completion of the program, Corporate Management Trainees are usually placed in our Operations or Brewing Divisions.

Find out how you can bring out your best at Anheuser-Busch by speaking with our recruiters when they come to your campus.

For more information and sign-up, please contact your placement office. ANHEUSER-BUSCH COMPANIES, INC.; Corporate Employment; College Relations; One Busch Place; St. Louis, Missouri 63118. An Equal Opportunity Employer M/F.

...Anheuser-Busch

ANHEUSER-BUSCH COMPANIES

Waste Not, Want Not

Three years of construction and planning was ended symbolically with the breaking of a bottle of American champagne last November 17. The celebration was the christening of *Vulcanus II*, Chemical Waste Management's new ocean incineration vessel.

The incineration process starts in the ship with its gorators, which change any solid wastes into a liquid form. This liquid is pumped hydraulically, at an average rate of over 5200 gallons per hour, to the rear of the ship, where three incinerators await in readiness at temperatures between 1250°C and 1500°C. Combustion occurs at an average rate of eight tons per hour, and the gaseous products are moved to the stack portions of the furnaces. Once there, any residual chlorine is converted to combustion gases which are sent into the ship's wake, where the sea water absorbs and neutralizes them.

Vulcanus II is 307 feet long, has a total capacity of 837,000 gallons, and has eight cargo tanks, each of which can be connected directly to the furnaces. The ship can destroy up to twenty million gallons of waste per year, which is necessary due to the demands for its services in both the U.S. and Europe. However, the U.S. market will supposedly exceed Europe's, and will steadily grow until 1990.

The new ship departed for its "initial survey burn" on December 10, in order to be certified by the U.S. EPA and IMCO. In mid-February, the vessel will be introduced to American government officials and industrial leaders in Washington, DC, and will then start servicing the U.S. waste market.

Chemical Waste Management, Inc., is a wholly owned subsidiary of Waste Management, Inc., and has its headquarters in Oak Brook, Ill.

Beam Me Up...

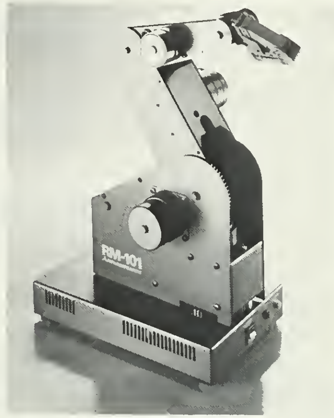
International Business Machines Corporation has started the first large-scale use of electron-beam methods to manufacture ROM's (read-only memory chips). Each chip is personalized, and can store up to 18,432 bits, which is about 400 words of data. The chips are used in IBM's most powerful central processing units (CPU's), which are the 3081, 3083, and 3084.

Before the new process was developed, IBM used an optical photolithographic process, involving a mask and chemicals, to etch the bit patterns on the chips. Now, the time is cut down to a third of its original length, as a computer-controlled electron beam tool directs electrons onto the chip to create the bit patterns. The chip is designed at IBM's Poughkeepsie, NY, facility, and the design information is sent via computer to their plant in East Fishkill, at the rate of one instruction per 8.5 nanoseconds. IBM also makes the personalized chips in Essonnes, France, using the same process. The whole process, from design to production, now takes about twenty days.

The chips are mounted onto thermal conduction modules (TCM's), which hold 118 of these chips. The TCM's are a major part of the computer's processor—they cool, protect, and interconnect the computer circuit components.

A Third Arm

Mitsubishi Electric now gives you that third arm you sometimes wish you had. It is called the RM-101 Movemaster, and it is a miniature robot. The Movemaster is ten inches high, and weighs under eighteen pounds. It can pick up about 1.125 pounds, has a maximum



grasp of 3.125 inches, and operates at up to 2.75 inches per second. Three separate hands are provided, in order to handle any task. There are six axes, each driven by a stepper motor, and five degrees of freedom of motion. The robot can be repeatedly repositioned, automatically, to positions within only three millimeters of each another.

Mitsubishi designed their robot to function exactly like the industrial ones used on assembly lines. Thus, the Movemaster is intended for use by schools, colleges, universities, and hobbyists. The robot comes with fourteen pages of instructions, and a Centronics printer interface to facilitate computer control. Inside is a microcomputer, so the movement instructions can be given in a simple robot language, and may be programmed using BASIC. Finally, the most important feature of this product is that it is built to withstand the trials and tribulations of novices.

Langdon Alger


If there's something out there, we know it.
We're Sanders.
It's our business to know if something's out there – be it friend or foe. In the sky. On the land. Under the sea. From beyond.
Special opportunities are waiting for people with degrees in Engineering, Computer Science, Physics or Math to join our forces in Software Development, Circuit & Systems Design and related proposal activities.
Find out what's out there for you.
On-Campus Interviews
Monday, February 28
See your Engineering Placement Office or send your resume and transcript directly to: College Recruiting Coordinator, Sanders Associates, Inc., 95 Canal Street, Nashua, NH 03061.
SANDERS
An Equal Opportunity/Affirmative Action Employer
U.S. Citizenship Required

Parker received his Bachelors in Mechanical Engineering (ME) from the North Carolina Agricultural and Technical State University in 1961. He began work on his Masters in ME while employed at Bell Aerosystems, and he received the degree from the State University of New York in 1969.

Professor Eisenstein received her undergraduate degree in physics in 1964 from Barnard College. In 1964 she earned her masters from Columbia University, and by 1969 she had received her doctorate in physics from Harvard University. Professor Eisenstein came to the University in 1967 where she was a research assistant doing work here for her PhD.

A native of Switzerland, Professor Wolfgang J. Poppelbaum received his Ph.D. in physics from the University of Lausanne in 1952. He came to the University in 1954 to work with John Bardeen on the development of the transistor, and he started teaching computer design classes right away.

Dean Paul E. Parker Engineering students with administrative problems seek solutions in 207 Engineering Hall. Located in 207 are the offices of the assistant deans, including Paul E. Parker.

In 1967, Parker joined the ME department of North Carolina Agricultural and Technical State University (NCA&T). He was appointed department chairman in 1970, and in 1971 he became assistant dean of the NCA&T College of Engineering. Parker became an assistant deans here at the University in 1973.

Parker acts as a counselor for students in the college. His duties include providing curriculum advice, handling transfer students, and working with co-op programs. Parker also serves as the coordinator of minority relations in the College.

Presently, Parker spends most of his time working with or for students. He also does some consulting work for companies such as Standard Oil, Inland Steel, and Union Carbide.
Raymond Hightower

Laura Eisenstein More than nine hundred students taking physics 108 were in for a pleasant surprise on the first day of class when Professor Laura Eisenstein, walked in to lecture.

After receiving her degree, Eisenstein worked as a research professor for two years, and from 1971-1980 she was a research assistant professor, teaching sections in physics 101, 106, and 108. She is now an assistant professor, and also teaches physics 321 and 322.

Among the professor's credentials are a NATO post-doctoral fellowship in Paris from 1973-1974 and a membership on the editorial board of *Biophysical Journal*. In June of 1983 she will be a member of the nomination committee of the the American Association for the Advancement of Science. She is member of the American Physical Society Committee on the Status of Women in Physics, and will chair that committee this January.

Currently, Eisenstein's main interest is biological physics. Specifically she is studying light induced reactions in biomolecules called rhodopsin (vision pigment) and bacterorhodopsin. *Steve Alexander*

Wolfgang Poppelbaum In 1954 Poppelbaum joined the Computer Laboratory research team in designing and building one of the first transistorized computers, the ILLIAC 2. He later became the director of the Computer Science department's Information Engineering Laboratory.

Poppelbaum is currently working with the multiplexing of information signals on optical fibers using "color modulation" and "spectrum sample transmissions". He is also working with computer speech processing systems, and a new kind of computer system called an "array" system in which internal information is "moved around much like a train."

Poppelbaum has published well over 40 technical articles along with several books, including a text on computer design. He is a Fellow of the IEEE, and has become well known as an expert in his field. He currently teaches CS 281, 381, and 497.
Gunnar Seaburg

One of the nation's top companies in sales of electronics-related equipment is Kodak.

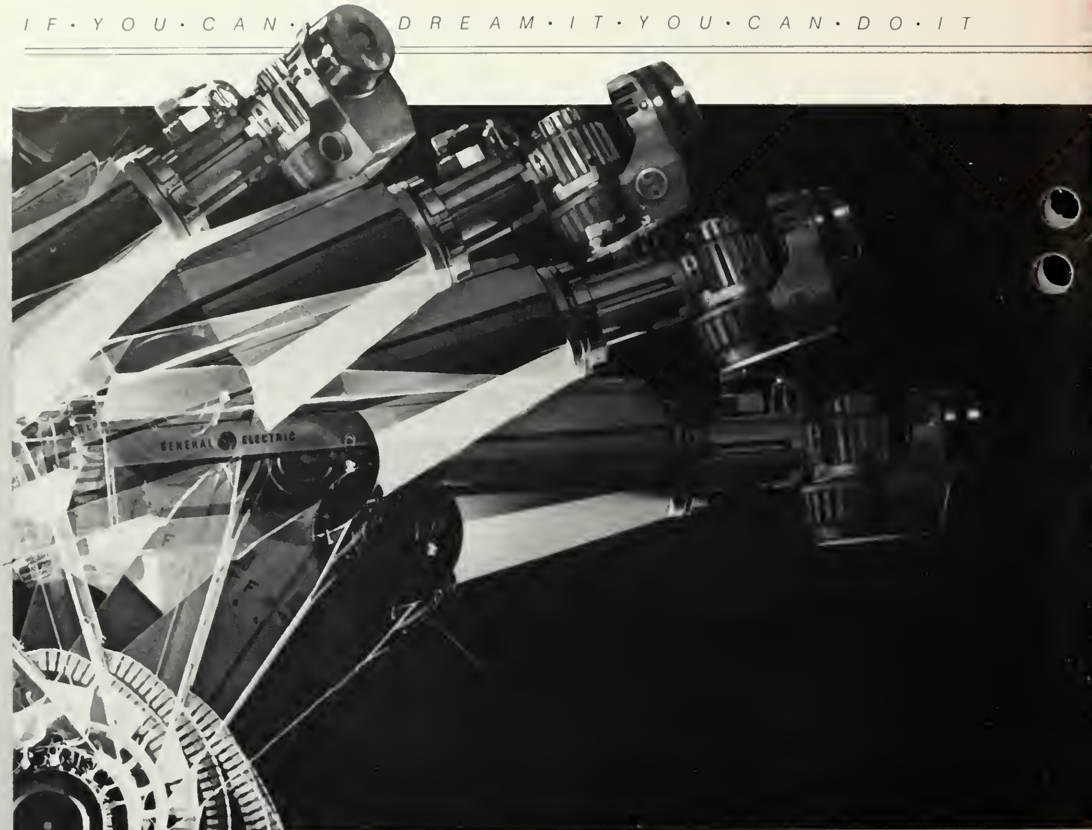
Kodak's application of electronics technology is becoming more and more extensive every day. That means we have growing career opportunities for electrical/electronics engineers.

In projects as diverse as the design and production of output driver chips for the logic and control unit of Kodak Ektaprint copier-duplicators. Development of advanced analog and digital technology and sophisticated software techniques for blood-chemistry analysis with the Kodak Ektachem 400 analyzer. And exploration of potential product improvements in the Kodak Komstar 300 microimage processor, a computer peripheral which uses pulsed laser beams to convert digital data to alphanumeric images on microfilm at speeds up to 20 times faster than many ink-jet paper printers.

If you want to expand your horizons to meet the Kodak challenge, see a Kodak recruiter on your campus. Or send your resume to: Personnel Resources, Dept. DECM, Eastman Kodak Company, Rochester, N.Y. 14650.

Kodak. The right place. The right time.

An equal opportunity employer manufacturing photographic products, fibers, plastics, chemicals, and electronic equipment. Plants in Rochester, N.Y., Kingsport, Tenn.; Windsor, Colo.; Longview, Tex.; Columbia, S.C.; Batesville, Ark.; and a sales force all over the U.S.



Teach a robot the facts of life.

There was a time when most robots earned their livelihoods in comic books and science fiction films.

Today, they're spraying, welding, painting, and processing parts at manufacturing plants around the world.

Necessity has caused this amazing leap from fantasy to factory.

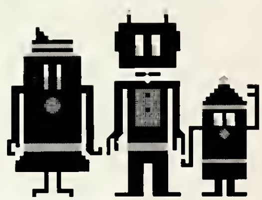
The world wants long-lasting, high quality products, now. And robots fit perfectly into this scheme of things: They can make those products – quickly, easily and accurately.

What kinds of robots? There is GE's Allegro,™ for one. It can position a part to within 1/1000th of an inch – or about ¼ the thickness of the paper this article is printed on. Or there's GP 132 (shown here). This loader, unloader, packer, stacker and welder – can lift and maneuver 132 pounds with no trouble at all.

So what's left for me to teach robots? You might ask. Consider this glimpse into the future by Dr. Roland W. Schmitt, head of GE corporate research and development:

"One of the big frontiers ahead of us is putting the robot's nervous system together with some senses – like vision, or touch, or the ability to sense heat or cold. That can give you an adaptive robot, one that can sense how well it's doing its job and make the adjustments needed to do that job better."

That's a tall order. And one we'll be expecting you to fill. With foresight, talent, imagination – all the things that robots have yet to learn.



WE BRING GOOD THINGS TO LIFE

An equal opportunity employer.